Synopsis

.

Methods of Quality of Service Satisfied Multicast Protocol

Using Soft Computing Techniques

By

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1. INTRODUCTION

Mobile Adhoc Networks (MANETs) are a type of wireless networks which do not need any backbone structure to transmit the data packets between mobile nodes such as an access point or a base station. Each mobile node acts as both host and router. The complexities and constraints known in traditional wireless networks are more prominent in MANETs due to dynamic topological changes, energy and bandwidth constraint.

A current trend for information-sharing applications is to transmit data packets in terms of multicast. Multicast services are a kind of group communication with which data packets are delivered simultaneously from the source to destinations. In order to multicast data packets, building a multicast tree is more efficient than sending the same packets individually from the source to destinations. A multicast protocol is delay-sensitive, if the delay requirements of the requested multicast services can be satisfied with specified confidence levels, i.e., specified percentages of data packets whose end-to-end delays are smaller than some predefined values.

To build a delay-sensitive multicast tree, both one-hop delay and end-to-end delay must be aware, where the one-hop delay (end-to-end delay) means the time required to transmit a packet between two neighboring hosts (from the source to some destination). When the contention-based IEEE 802.11 MAC is used, the one-hop delay includes channel contention time (and packet transmission time), which is difficult to estimate, because of the shared radio channel. MAC standards like 802.11a, 802.11b and 802.11g can operate with multiple data rates due to significant advances in wireless modulation technologies for Quality-of-Service (QoS)-constrained multimedia communication in order to utilize the limited resources of MANETs more efficiently.

However, the maximal data rate with which the transmitter can transmit packets successfully depends on the signal-to-interference and- noise ratio (SINR) perceived by the receiver. The SINR value is inversely proportional to the transmission range. When the transmitter uses a higher data rate, the receiver has to perceive a higher SINR, which further requires a shorter transmission range for the transmitter, in order to have a successful transmission. Thus, in multirate MANETs, the neighborhood of a host may vary, which causes it more difficult to estimate the one-hop delay (and end-to-end delay). When designing a QoS routing (or multicasting) protocol for a MANET, its neighboring information should be maintained for estimating the resource consumed by the constructed QoS route and its neighbors in order to

avoid resource violation of it and its neighbors. It is also desired that the obtained QoS routing (or multicasting) protocol can utilize the limited wireless resources more efficiently (e.g., admit more requested flows).

Multicast routing protocol based on multirate MANETs [1–2] were designed for effective multicast transmission. But, they were neither bandwidth guaranteed nor delay sensitive, and suffer from the hidden route problem (HRP) or the hidden multicast route problem (HMRP) [3], as a consequence of failing to collect neighboring information for estimating the resource consumption.

A delay-sensitive routing protocol [4] was developed in multirate MANETs by constructing a single route which can avoid HRP but cannot avoid HMRP while permitting single route at a time. Different from [4], a delay-sensitive multicast protocol for multicast services in multirate MANETs was proposed [5] for determining multiple delay-sensitive routes concurrently from a server to all clients. It not only can avoid HRP, but can avoid HMRP while permitting multiple flows concurrently. Further, the end-to-end delays of the determined multicast tree will be smaller than the delay requirement of the requesting multicast service with a certain confidence level. On the other hand, since higher data rates can render one-hop delays smaller, most of the previous routing/multicasting protocols selected forwarders with higher data rates. However, higher data rates also cause more forwarders to participate in packet forwarding along the routes. When a forwarder is transmitting packets, its carrier sense neighbors must be blocked. So, the network performance will worsen, if there are too many forwarders. This multicast protocol intends to minimize the sum of the total transmission time of the forwarders and the total blocking time of the blocked hosts by taking the neighboring information of the forwarders into account and properly adjusting the data rates of the forwarders, while constructing the multicast tree.

There are other QoS requirements, e.g., bandwidth, packet dropping rate, and delay jitter, for real-time applications were not considered in above researches. This research aims to propose protocol by considering these requirements while reducing power utilization while multicasting.

2. LITERATURE SURVEY

Singal et al. [6] proposed a multi-constraints link stable multicast routing protocol in MANETs. In this protocol, a QoS-aware metric was used to determine the stable link among all incoming links based on the link stability factor. The stability factor was estimated by using contention count, received signal strength and hop count as QoS parameters. Then, the node with the highest stability factor was chosen as a forwarding node. Similarly, the link with the highest link stability factor was chosen as the most stable link. However, an appropriate contention count should choose to achieve well connectivity and availability of resources.

Yadav et al. [7] proposed an Efficient Fuzzy-based Multi-constraint Multicast Routing Protocol (EFMMRP) that considers multiple QoS performance constraints such as end-to-end delay, channel bandwidth and energy. In this protocol, such constraints were converted as a fuzzy cost to assign the multicast route for data transmission between the source and set of destinations having a low value of fuzzy cost. On the other hand, the control overhead was high.

Subramaniam & Tamilselvan [8] developed resource assignment and rate adaptation scheme for multicast of real-world traffic in MANET. In this scheme, a reservation protocol was applied when transferring the real-world information to reserve upcoming slots. Also, a three hop slot allocation method was adopted for providing an intrusion free framework. Moreover, a normalized transfer rate was employed for characterizing the transfer rate adoption. But, the packet delivery ratio was less and latency was high.

Gawas et al. [9] designed a new cross-layer communication between the network layer, MAC and PHY. Also, the correlation between the data rate, congestion metric and MAC latency in latency-sensitive purposes were computed for improving the network efficiency. Moreover, multiple node-disjoint paths were found and optimal data rates were computed between the paths according to the computed latency that facilitates the flow with the specific latency demand in multirate MANET. But, the packet delivery ratio was less while increasing the mobility speed.

Papanna et al. [10] designed an Energy-Efficient Lifetime-Aware Multicast (EELAM) path decision scheme with the help of an adaptive genetic algorithm. It was depending on the tree topology that differentiates other trees in accordance with the multicast routing topologies by

adapting a genetic algorithm. Based on this scheme, optimized amount of intermediary nodes with the maximum residual energy and the minimum energy depletion were decided. But, it was time-consuming.

Banerjee & Ghosh [11] designed a Weight-based Energy-Efficient (WEEM) protocol in MANETs. In this WEEM, if multiple routes were predicted to stay active till the multicast session, then the weight was allocated to the routes by the target node. The route having the maximum weight was decided as the best. This weight was determined by considering the remaining power and multicast data transfer ability of nodes in the route including the amount of multicast targets situating in that route. If multiple routes have equal weights, then the route with the minimum latency was assigned a higher priority. But, the control overhead was not efficiently reduced.

Al-Sharah & Alhaj [12] proposed a novel adaptation method, namely hand-shake transmission ratein which cooperative game was adopted. Based on this method, the accurate transmission rates were chosen by the nodes according to the bandwidth requirements. Also, a decentralized method was applied to adjust the transmission rates between adjacent nodes. The knowledge of adjacent node's transfer rates was used to facilitate the individual node for optimizing the rates in specific bandwidth demands. But, the overall performance was not effective while increasing the number of nodes.

The limits observed in regard to these benchmarking models is that the multicast scope of a node is not considered and no evidence of accurate selection of multicast route with minimal energy consumption and maximum lifetime, which are significant in establishing stable route.

3. PROBLEM DEFINITION

The problems considered for this research work are the following:

- In DSM protocol, the delay was only considered to construct a multicast tree which does not increase the QoS guarantees of the network.
- As transmission ranges of hosts rely on the data rates, the selection of proper data rate for hosts was difficult which degrades the transmission rate significantly.
- The network lifetime was reduced rapidly due to high transmit power. The dynamics of the buffer were not considered which causes the high packet loss and delay.

4. OBJECTIVES OF THE RESEARCH

The objectives of this research are defined as follows:

- To accomplish QoS-satisfied multicast routing in MANET by considering different network metrics such as delay, bandwidth, packet loss rate and jitter.
- To increase the transmission rate by selecting the proper data rate for hosts based on the deep learning algorithm.
- To develop a lifetime-aware routing protocol for reducing the transmit power of nodes and increasing the network lifetime.
- To reduce the packet loss rate and delay efficiently based on the dynamic hop-aware buffering scheme.

5. RESEARCH METHODOLOGIES

5.1 A QoS-Satisfied Multicast Routing Protocol for Enhancement on Network Performance of Multirate MANETs

In DSM protocol, a multicast tree was built which minimizes the total transmission period of the forwarders and the blocking period of the blocked hosts with the help of adjacent information of the forwarders. Besides, the transmission data rates of the forwarders were adjusted to decrease resource usage. Conversely, additional QoS metrics were needed to enhance the network and routing efficiencies. So, in the phase of the research work, QoS-Satisfied Multicast protocol using Multiple rate (QSSM-M) is proposed which utilizes additional QoS metrics, including bandwidth, packet dropping rate and jitter. First, such QoS metrics are determined and observed from each neighboring node. After that, many QoS-satisfied multicast trees are built based on the observed metrics where each multicast tree can satisfy the predefined rate of the QoS demands. Also, a randomized network coding is applied to reduce the redundant packets and thus each target node receives the new coded packets from multiple paths. Thus, the overall latency and bandwidth usage of each node is reduced while ensuring QoS to a requested traffic flow and ongoing flows.

5.2 A Selection of Data Transfer Rate using Deep Learning for QoS-Satisfied Multicast Routing Protocol in Multirate MANETs

In this phase of the research work, a QoS-Satisfied Multicast with Multiple Learned (QSSM-ML) rate-based routing protocol is proposed to allocate proper transmission data rates for hosts. First, the issue of allocating the data rates for hosts is devised as a multiclass categorization dilemma and solved via learning the Deep Convolutional Neural Network (DCNN) under supervised learning. Different network parameters together with the payload length of transfer frames, transmission link quality and throughput are determined while satisfying the stable False Error Rate (FER). After determining all the parameters, DCNN is applied to learn and predict the appropriate transmission data rates for hosts. Thus, this QSSM-ML protocol can enhance the transmission rates effectively for successful data exchange in multirate MANETs.

5.3 Extending Lifespan MANETs by Optimized Transfer Energy Distribution in QoS-Satisfied Multicast Routing Protocol

Even if the network throughput is increased, the network lifespan is not sufficiently improved due to the high power depletion. So, in this phase of the research work, an Extending Lifespan and QSSM-ML (ELQSSM-ML)-based routing protocol is designed which lessens the power usage and improves the network lifespan. Initially, an optimization problem is modeled based on an objective of maximizing the MANET's lifetime whilst maintaining the energy usage, remaining energy and path stability. After that, an asymmetric transmit power strategy by using the Lagrangian multipliers is developed to adaptively assign the transmit power at both origin and intermediary nodes. Thus, this ELQSSM-ML protocol can decrease power consumption and enhance the network lifespan significantly.

5.4 Adaptive Buffer Handling with Optimal Power Allocation-based QoS-Satisfied Multicast Routing Protocol

In this phase of the research work, an Extending Lifespan and Enhanced QSSM-ML (ELEQSSM-ML)-based routing protocol is proposed which integrates an adaptive hop-aware buffer handling mechanism to avoid packet loss effectively. At first, the buffer size of each node is partitioned into different segments according to the number of hops and QoS for multiple classes of packets. After that, the dimension of each segment is adaptively fine-tuned based on the traffic load and reliability thresholds. To avoid packet loss efficiently, the reliability thresholds for each class of packets are optimized by the reinforcement learning strategy. Thus, this ELEQSSM-ML protocol can minimize packet loss, bandwidth usage, latency and increase the success rate significantly.

6. METHODOLOGY FLOW

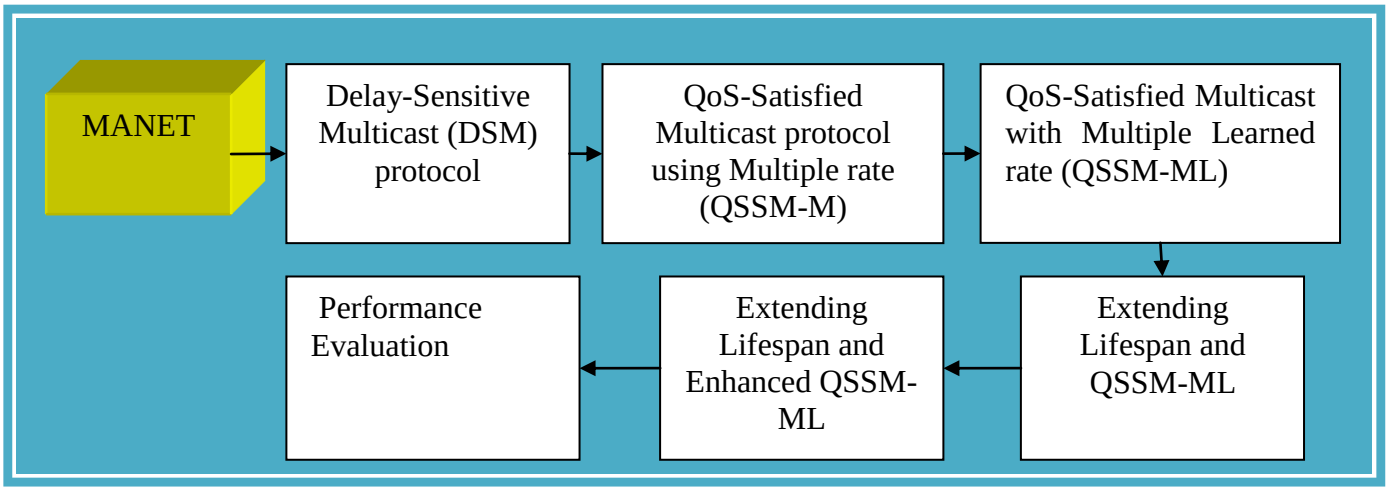
MANET
Delay-Sensitive Multicast (DSM) protocol
QoS-Satisfied Multicast protocol using Multiple rate (QSSM-M)
QoS-Satisfied Multicast with Multiple Learned rate (QQSSM-ML)
Extending Lifespan and QSSM-ML
Extending Lifespan and Enhanced QSSM-ML
Performance Evaluation

Figure 1. Block Diagram of Extending Lifespan and Enhanced QSSM-ML Protocol

Figure 1 represents the diagrammatic view of all four proposed methods. The step by step improvements in the each phase of proposed protocol finally achieve expected result in terms of all parameters of simulation experiments. Simulation experiments and simulation parameters are briefly explained in the next section. A formulated optimization problem is solved with a purpose of increasing the network's lifetime while limiting the utilization of energy, residual energy and path stability.

7. SIMULATION RESULTS AND DISCUSSIONS

The effectiveness of QSSM-M, QSSM-ML, ELQSSM-ML and ELEQSSM-ML-based routing protocols is assessed by modeling them in Network Simulator version 2.35 (NS2.35). Also, their efficiencies are compared with the existing protocols such as DSM-Single (DSM-S) rate-based and DSM-Multiple (DSM-M) rate-based routing protocols regarding different network metrics. The considered simulation parameters are presented in Table 1.

Table.1 Simulation Parameters

Parameters	Value
Simulation area	$1000\times1000m^2$
No. of nodes	100
MAC category	IEEE 802.11
Channel category	Wireless channel
Antenna	Omni-directional

Propagation category		Two ray ground
Required bandwidth		500 kbps
Packet's header length		10 bytes
Packet's payload length		512 bytes
Batch size for randomized network coding		32
Multiplying variable		1.2
Queue size		64 packets
Traffic category		Constant Bit Rate (CBR)
Q_{fix} to generate multicast trees		0.3
Timeframe between 2 successive tree refreshes		4
Data rate		11 Mbps
Transmit energy		0.0316 W
Simulation interval		200 sec
Control packet length	$hello$	160 bytes
	$table\_query$	10 bytes
	$table\_reply$	1500 bytes
	$route\_query$	10 bytes
	$route\_found$	20 bytes

7.1 1-Hop Delay

It is the time required to disseminate a data from every node to the other.

$$l_n = MAC\_l_n \times Exp\_data_n \tag{2}$$

Where $MAC\_l_n = \left(Exp\_bf\_slot_n \times \left(1 + \frac{b}{n\_rate_n}\right) + Exp\_slot_n\right) \times Exp\_effort_n$

(3)

$$\left(\frac{b}{n}\right)^{f}_{\_rate_n} = \frac{b\_slot_n + b\_slot\_occp_f}{n\_slot_n - b\_slot\_occp_f} \tag{4}$$

In Eq. (2), l_n is the 1-hop latency of n^{th} node, MAC_l_n is the MAC access latency of a data disseminated from n and Exp_data_n is the expected amount of data in the MAC queue of n at a stable period. In Eq. (3), $Exp\_bf\_slot_n$ is the expected amount of backoff

duration slots of n at a stable period, $\frac{b}{n}_{\_rate_n}$ is the busy/free channel ratio obtained by n at a specified period, Exp_slot_n is the expected amount of period slots essential for n to disseminate the data at a specified period and Exp_effort_n is the expected amount of broadcast attempts by n at a specified period. In Eq. (4), $\left(\frac{b}{n}\right)^{f}_{\_rate_n}$ is the busy/free channel ratio obtained by n in a specified period with a required traffic/packet (f) agreed, b_slot_n is the amount of busy period slots noticed by n in a specified period, n_slot_n is the amount of free period slots noticed by n and $b\_slot\_occp_f$ is the amount of busy period slots occupied by f.

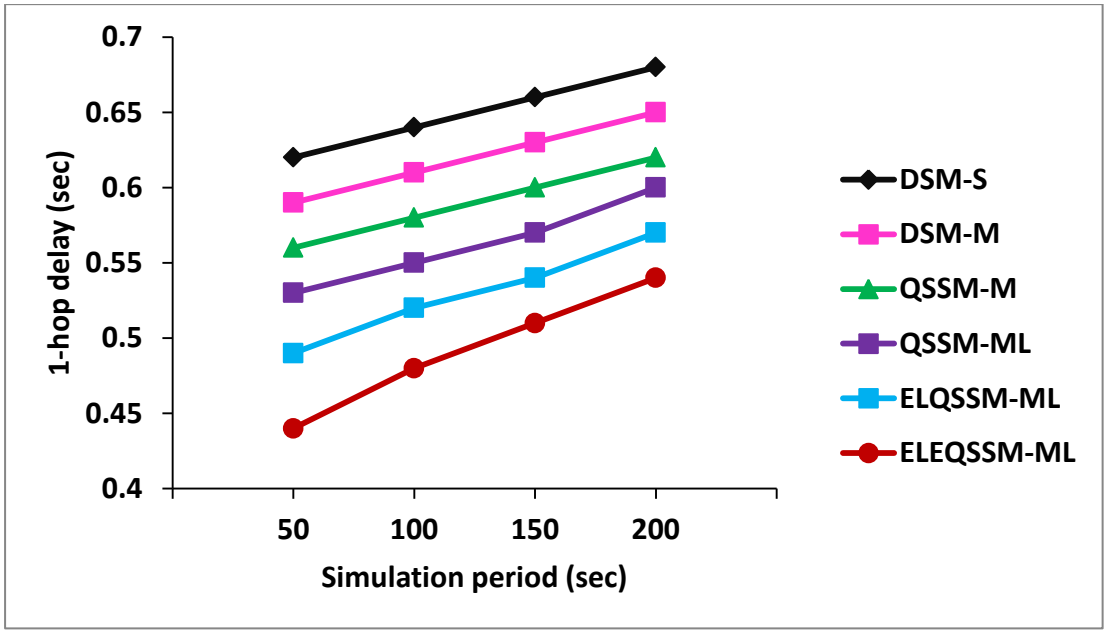

Figure 2. 1-hop Delay vs. Simulation Period

Figure 2 portrays a 1-hop delay (in sec) for different proposed and existing multi-cast routing protocols under a varying simulation period (in sec). It signifies that when increasing the simulation period, the ELEQSSM-ML-based routing protocol can decrease 1-hop delay than the other protocols, i.e., 1-hop delay of ELEQSSM-ML for simulating 200sec is 20.59% less than the DSM-S, 16.92% less than the DSM-M, 12.9% less than the QSSM-M, 10% less than the QSSM-ML and 5.26% less than the ELQSSM-ML protocols. This is because of choosing the proper data rate and reducing the redundant transmissions via multiple routes.

7.2 End-to-end Delay

It is the time needed to disseminate the data between the source and the multiple target nodes.

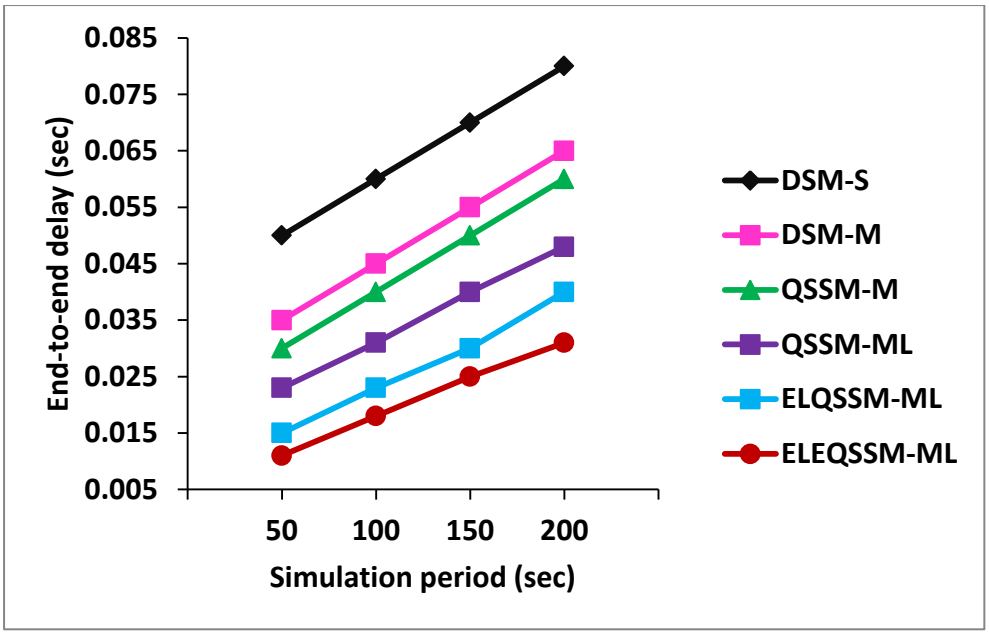

Figure 3. End-to-end Delay vs. Simulation Period

Figure 3 illustrates the end-to-end delay (in sec) for different proposed and existing multi-cast routing protocols under a varying simulation period (in sec). It indicates that the ELEQSSM-ML-based routing protocol can decrease end-to-end delay than the other protocols when increasing the simulation period. This is due to the selection of the appropriate data rate and ensuring the QoS demands of multicast routing in multirate MANET. For simulating the network in 200sec, the end-to-end delay of ELEQSSM-ML is 61.25% less than the DSM-S, 52.31% less than the DSM-M, 48.33% less than the QSSM-M, 35.42% less than the QSSM-ML and 22.5% less than the ELQSSM-ML protocols.

6.3 Success Rate

It is the proportion of amount of data delivered effectively at the target to the amount of data disseminated from an origin.

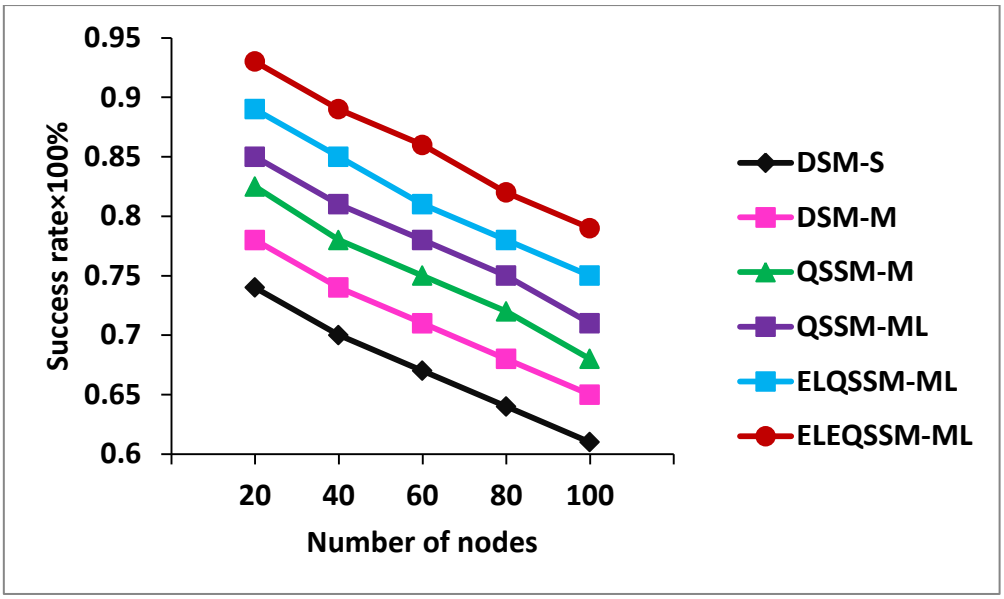

Figure 4. Success Rate vs. Number of Nodes

Figure 4 depicts the success rate (×100%) for different proposed and existing multi-cast routing protocols under a varying number of nodes. It observes that the ELEQSSM-ML-based routing protocol can improve the success rate i.e., packet delivery rate than the other protocols for the different number of nodes. This is because handling the buffer size of nodes which reduces the packet loss and delay effectively than all other protocols. For 100 nodes in the network, the success rate of ELEQSSM-ML is 29.51% greater than the DSM-S, 21.54% greater than the DSM-M, 16.18% greater than the QSSM-M, 11.27% greater than the QSSM-ML and 5.33% greater than the ELQSSM-ML protocols.

6.4 Admittance Rate

It is the ratio of the amount of accepted multicast traffic to the amount of preferred multicast traffic.

Figure 5 explains the admission rate (×100%) for different proposed and existing multi-cast routing protocols under a varying number of nodes. It analyzes that the ELEQSSM-ML-based routing protocol can increase the admittance rate compared to the other protocols for the varying amount of nodes. This is achieved as a consequence of

optimizing the data rate and satisfying the QoS efficiency compared to all other protocols. For instance, the admittance rate of ELEQSSM-ML using 100 nodes is 74.07% higher than the DSM-S, 56.67% higher than the DSM-M, 38.24% higher than the QSSM-M, 23.68% higher than the QSSM-ML and 11.9% higher than the ELQSSM-ML protocols.

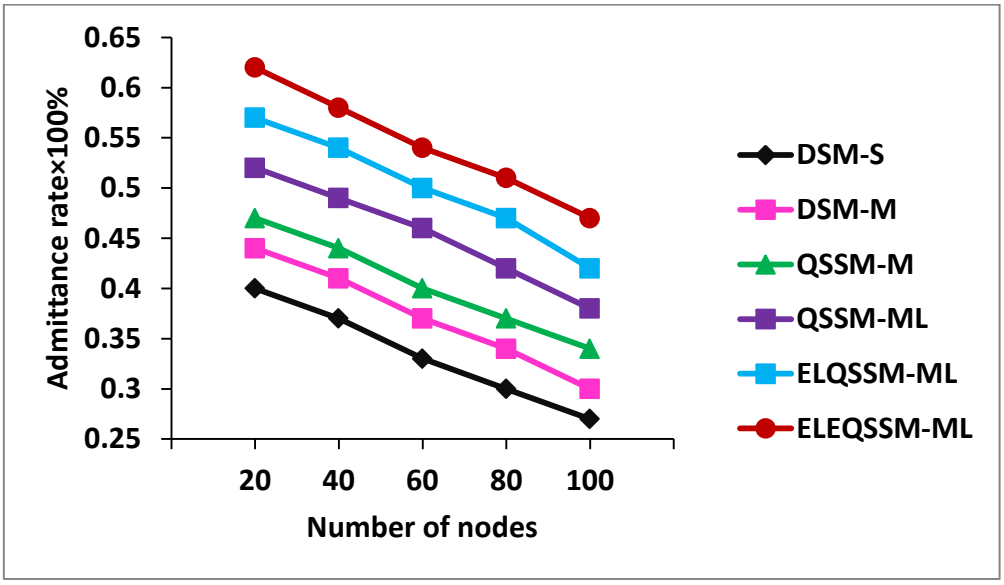

Figure 5. Admission Rate vs. Number of Nodes

6.5 Number of Control Bytes

It is the amount of control bytes transmitted per data.

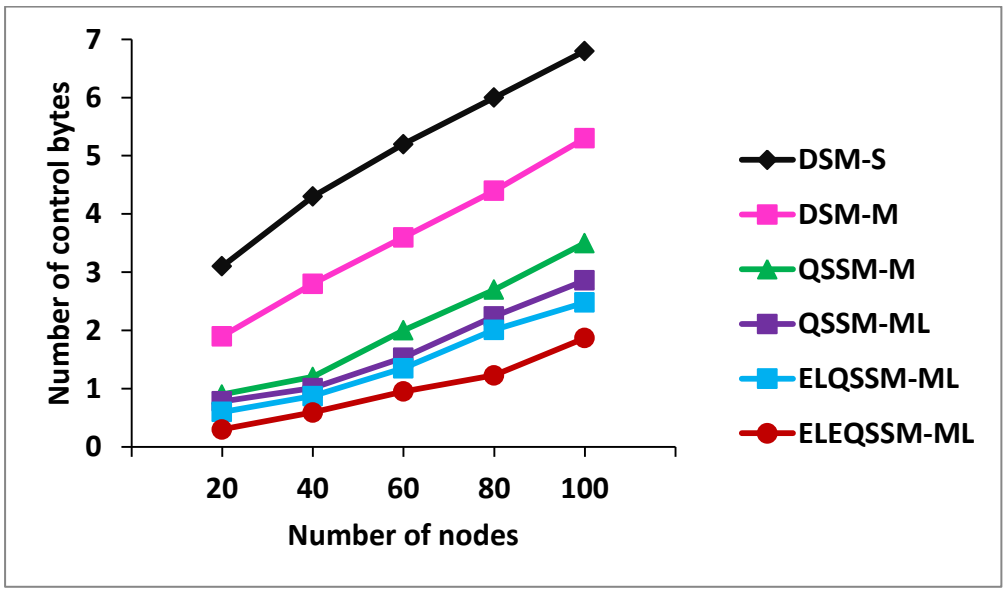

Figure 6. Number of Control Bytes vs. Number of Nodes

Figure 6 illustrates the number of control bytes for different proposed and existing multi-cast routing protocols under the different number of nodes. It analyzes that the ELEQSSM-ML-based routing protocol can lessen the number of control bytes than the other protocols for the different number of nodes that exist in the network. For the case of 100 nodes, the number of control bytes used for ELEQSSM-ML is 72.5% less than the DSM-S, 64.72% less than the DSM-M, 46.57% less than the QSSM-M, 34.62% less than the QSSM-ML and 24.6% less than the ELQSSM-ML protocols.

7. CONCLUSION

This research work proposes the protocols to enhance the QoS performance of the multicast routing in multirate MANETs. Initially, the QSSM-M protocol was proposed to create the QoS-satisfied multicast tree by considering bandwidth, packet loss rate and jitter for each adjacent node which ensures the QoS demands of multicast routing. Then, the QSSM-ML was developed using DCNN to choose the suitable data rate for the host and increase the success rate. Additionally, the ELQSSM-ML protocol was proposed to extend the network lifespan by optimizing the transmit power of source and relay nodes based on the Lagrangian multipliers. Further, the ELEQSSM-ML protocol was designed using the reinforcement learning-based adaptive hop-aware buffer management strategy to handle the buffer size of each node and reduce the packet loss successfully. At last, the simulation findings proved that the ELEQSSM-ML-based multicast routing protocol has 0.4925sec mean 1-hop delay, 0.0213sec mean end-to-end delay, 85.8% mean success ratio, 54.4% mean admittance ratio and 0.988 mean number of control bytes compared to the all other multi-cast routing protocols in multirate MANETs.

8. LIST OF PUBLICATIONS

1) R. Suganya, and Dr. Vasantha Kalyani David,"Extending Lifespan MANETs by Optimized ransfer Energy Distribution in QoS-Satisfied Multicast Routing Protocol", Design Engineering (Toronto), Issue: 8 **,** ISSN:0011-9342.

2) R. Suganya, and Dr. Vasantha Kalyani David," QoS-Satisfied Multicast Routing Protocol for MANETs", International Journal of Intelligent Engineering and Systems , Vol.14, No.4, 2021 ISSN: 2185-3118.

3) R. Suganya, and Dr. Vasantha Kalyani David, "QoS-satisfied Multicast Routing Protocol For Enhancement On Network Performance Of Multirate Manets" , 10th National Conference on Machine Learning & Smart Technology (NCMLST'20) on 12th Feb 2020, ISBN 978-93-89515-11-4, Page no:160.

4) R. Suganya, and Dr. Vasantha Kalyani David,"A Selection of Data Transfer Rate using Deep Learning for QoS-Satisfied Multicast Routing Protocol in Multirate MANETs", IEEE International Conference on Mobile Networks and Wireless Communications (ICMNWC) on 3 - 4 December 2021 in association IEEE Bangalore Section.

5) R. Suganya, and Dr. Vasantha Kalyani David,"Adaptive Buffer Handling With Optimal Power Allocation-based QoS-satisfied Multicast Routing Protocol", International Journal of Innovative Science and Research Technology , ISSN No:-2456-2165 .

6) R. Suganya, and Dr. Vasantha Kalyani David, "A Survey On Delay-aware Multicast Routing Protocols In MANET", Journal of Emerging Technologies and Innovative Research (JETIR), Volume 6, Issue 6, (ISSN-2349-5162).

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